[redacted]

Refer: R11-985

To: [redacted] 25X1

cc:

Systems Management & Engineering Dept.
Digital Controls & Electronics Section

Subject: Project 135 - Optical System

From: F. S. 1 November 1965

This memorandum has been generated to establish the background and to discuss the solution to the technical problems encountered in the development of the optical system for the Universal Data Block Reader.

ACCURACY REQUIREMENTS

Section 4.4.3 of Proposal SME-PR-09 outlined the method by which the reader would correct for wander of the film in both the camera and the reader itself. This system employed a read head containing 108 diodes, each spaced .006 inches apart. The diodes are grouped in three sets, A, B, and C creating three separate heads, interlaced with each other. As the film wanders, the distance between the edge of the film and the index bit of the data block will vary. A window of 12 diodes, 4 of each group, is used to locate the index bit. Since the wander varies continuously, and the resolution of the head is .006", the index bit may fall under any one or more of the 12 diodes in the window. Ideally, with a perfect dimensional match between the diode array and the data block, when the window picks up an index dot with a diode belonging to one group, all dots in the data file will also be picked up by the diodes in the same group. In actuality, a perfect match cannot be achieved and certain tolerances have to be considered. The following analysis will establish the maximum tolerable dimensional deviation which allows reliable reading.

The smallest geometric coverage of any diode will occur when the minimum size dot of .006" will be evenly covered by two adjacent diodes, such that each diode will see one half of a dot or .003" of area coverage. The threshold of the read amplifiers is set to recognize .002" of coverage as a dot. Therefore, if any one diode group is selected, only .001" total deviation from nominal is allowed between the index dot image and the image of any other dot in the data block. By changing the logical scheme to one in which a split coverage of a dot by two adjacent diodes activates both diode groups, the allowable tolerance is doubled. This will effectively widen the pickup area of each head increment to .012" instead of the .006" of a single diode.

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Under this scheme, the worst case condition is no longer the one described previously. Instead, the tightest dimensional accuracy will be required when a .006" dot will be covered unevenly by two diodes - one diode covering .004" and the other .002". Because of the amplifier threshold, the diode covering the .002" portion of the dot is on the verge of being ignored, and only one diode, the one with the .004" coverage, will provide a reliable output. Under these conditions, only one diode group will be selected, and the tolerable dot deviation is .002".

Since the diode array is dimensionally accurate to .0003" and the film shrinkage can reduce the recorded block by .0002", the system has an inherent basic inacurracy of .0005". Allowing another .0005" for film thickness variations and a safety margin, a tolerance of .001" is left for the optical system.

OPTICS

When the optics for the Universal Data Block Reader were initially considered, it was known that a lens similar to that employed in the KA-56 camera for the ADAS system would be necessary. Due to the tolerances of the data block, both systems require a low distortion lens. The ADAS system utilizes a cathode ray tube as a light source and imaged the source on panchromatic film. The light given off by the particular phosphor used in the ADAS tube is located completely in the blue region of the visible spectrum. Therefore, the focus of the ADAS lens is corrected for blue light. The silicon photodiode response unlike that of panchromatic film, lies in the infrared region. Therfore, the Universal Data Block Reader will employ a tungsten lamp as a light source to closely match the response of the diode. To provide optimum results, the lens employed in the reader must be corrected for a portion of the red region of the spectrum. However, initial testing of the read head using the ADAS lens indicated that sufficient signal was present and it was decided to use the ADAS lens for breadboarding purposes only, with a detailed analysis to follow at a later date to insure that the distortion characterisitcs due to the chromatic variation of magnification would be acceptable. Whether or not the distortion was acceptable would not affect the amplifier design.

Presented to DS - Stayer + Post 3 Nov 65.

At this writing the analysis of the distortion characteristics has been completed. It has been found that the ADAS lens, while satisfactory in the blue region, of the visible spectrum for which it was originally designed, when used in far red (and infrared) region creates a condition which is marginal from a system viewpoint.

The lens exhibits approximately .012" (computed), .016 measured axial focal shift over the spectral region of 0.450 mu to 0.800 mu. This is considered excessive for two reasons. One is the effect it will have on the image size and the other is the effect on magnification. The chromatic growth of the image of a dot will be in excess of that defined by the system requirements. It will be in excess of .001" on the diameter. If one considers the full change in scale (magnification) with wave length, i.e. $\frac{.012}{2} \times 100\% = .6\%$ it can be shown that this exceeds the required position accuracy of the system. Therefore, the ADAS lens would seem to be one which is not capable of providing a usable image for this particular system.

PROGRAM IMPACT

From the aforementioned analysis it is seen that a low distortion mapping type lens, corrected in the red region, is required. While the technology for designing and manufacturing such a lens exists, the need for this type of a lens, to our knowledge, has not arisen in the past. Therefore, a new lens must be designed. It is the opinion of the writer that this new requirement will delay Phase I of the program approximately three (3) months. The physical time of performance of Phase II should not be affected. However, the starting time will be delayed by the amount of time that Phase I slips.

This info was furnished Rast + myself at a meeting with [redacted] 25X1
[redacted] on 3 Nov 65. We feel this is a problem that sh 25X1
recognized from the start and as such should have been considered + worked out before proposing and it is not a new design characteristic. The impact, in addition to the ± 3 month is an additional 15K for lens design + manufacture. This cannot be considered a change in scope as we have not changed requirements in this area.

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Refer: F12-191

Systems Management & Engineering Dept.
Digital Controls/Electronics Section

To: [redacted]

Subject: Scanning ~~Photodiode~~ Phototransistor Array 25X1

From: C. P, H. S. 4 March 1965

This memo will describe the equivalent circuit and operation of a scanning photodiode array supplied by the Transducer Research section [redacted] 25X1
Also included are experimental results obtained operating the device.

The array features 50 photodiode elements which are scanned to produce a single serial output. The scanning is performed by the application of a voltage waveform consisting of a ramp or a staircase.

Figure 1 illustrates the equivalent circuit of the array and its connection into a circuit. The collector to base junctions of transistors Q1 through Q50 act as photodiodes when reverse biased. Light generated charges act as base currents turning on the transistors which supply amplification.

The bias supply generates a potential drop accross the distributed collector resistor making the collector potentials of transistors Q1 through Q50 progressively lower. The output of the scan generator at the start of operation applies forward bias to the collector to base junction of transistor Q1. This is true for each transistor and the junction cannot act as a photodiode. The base to emitter junctions meanwhile are all reversed biased preventing the flow of current in the output line.

As the sweep voltage increases, the collector to base junction of Q1 will become reverse biased and act as a photodiode. Light generated current will act as a base signal and is amplified. The amplified current flows in the output line. As the sweep voltage becomes progressively larger, the other transistors will sequentially operate.

The device supplied by [redacted] had junctions with active areas of 0.003 inches by 0.007 inches placed on a 0.010 inch pitch. Figure 2 illustrates the measured transfer gain of the array. The experimental circuit shown in Figure 3 was used. 25X1

The experimental data indicates an element output of current of 750 nano-amperes for a 50 foot candle input. The calculation for the theoretical expected value is given as:

$$i = I\,K_D\,A\,\beta$$

I = light intensity (50 ft. candles)
K_D = diode constant (30×10^{-12} ampere/ft. cand/sq. mil)
A = diode area (21 square mils)
β = transistor gain (25)

$$i = 790 \times 10^{-9} \text{ amperes}$$

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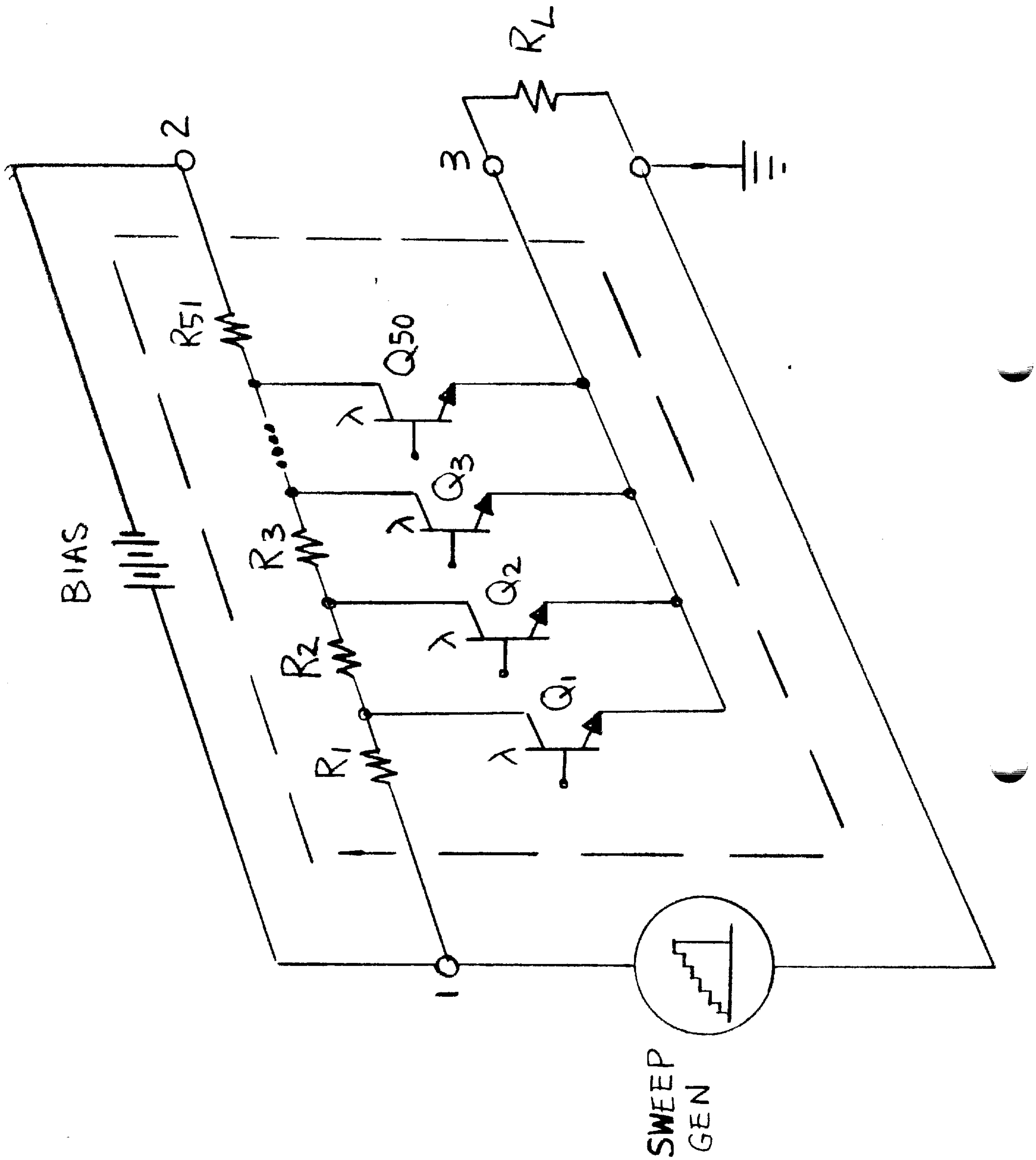
FIGURE I SCANNING PHOTODIODE ARRAY



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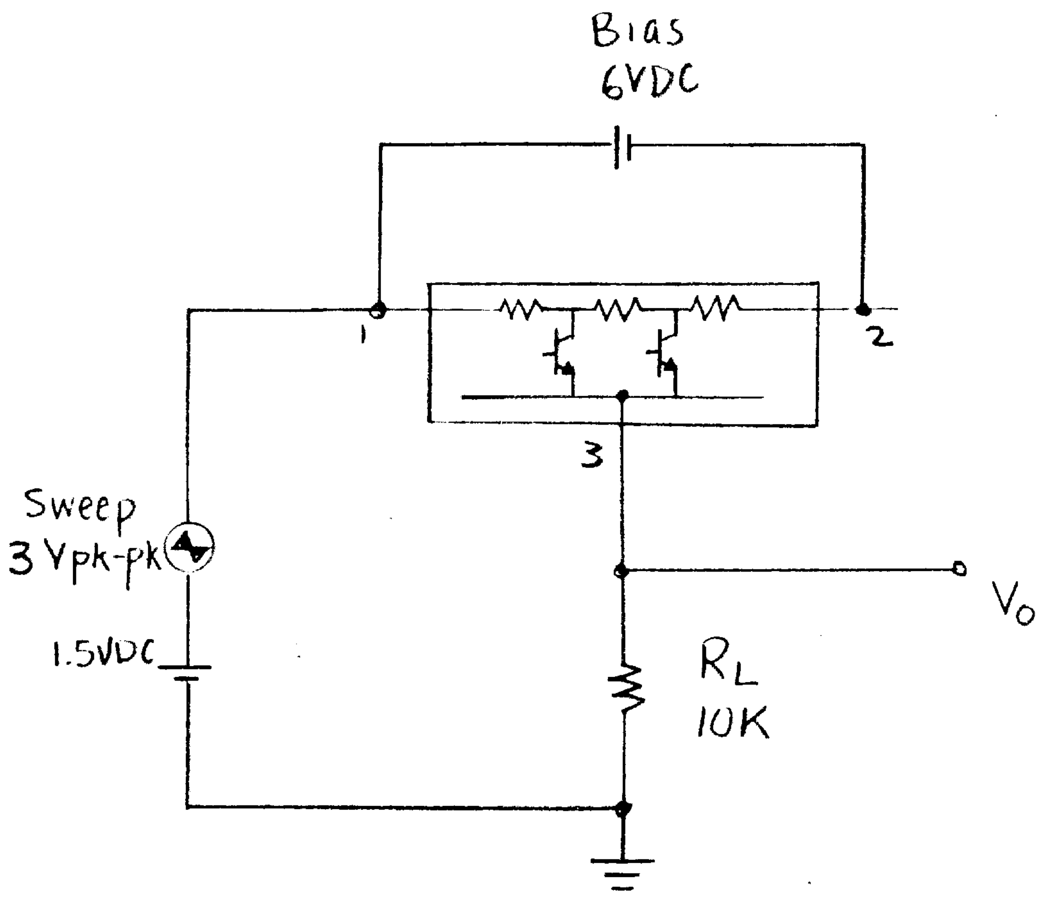
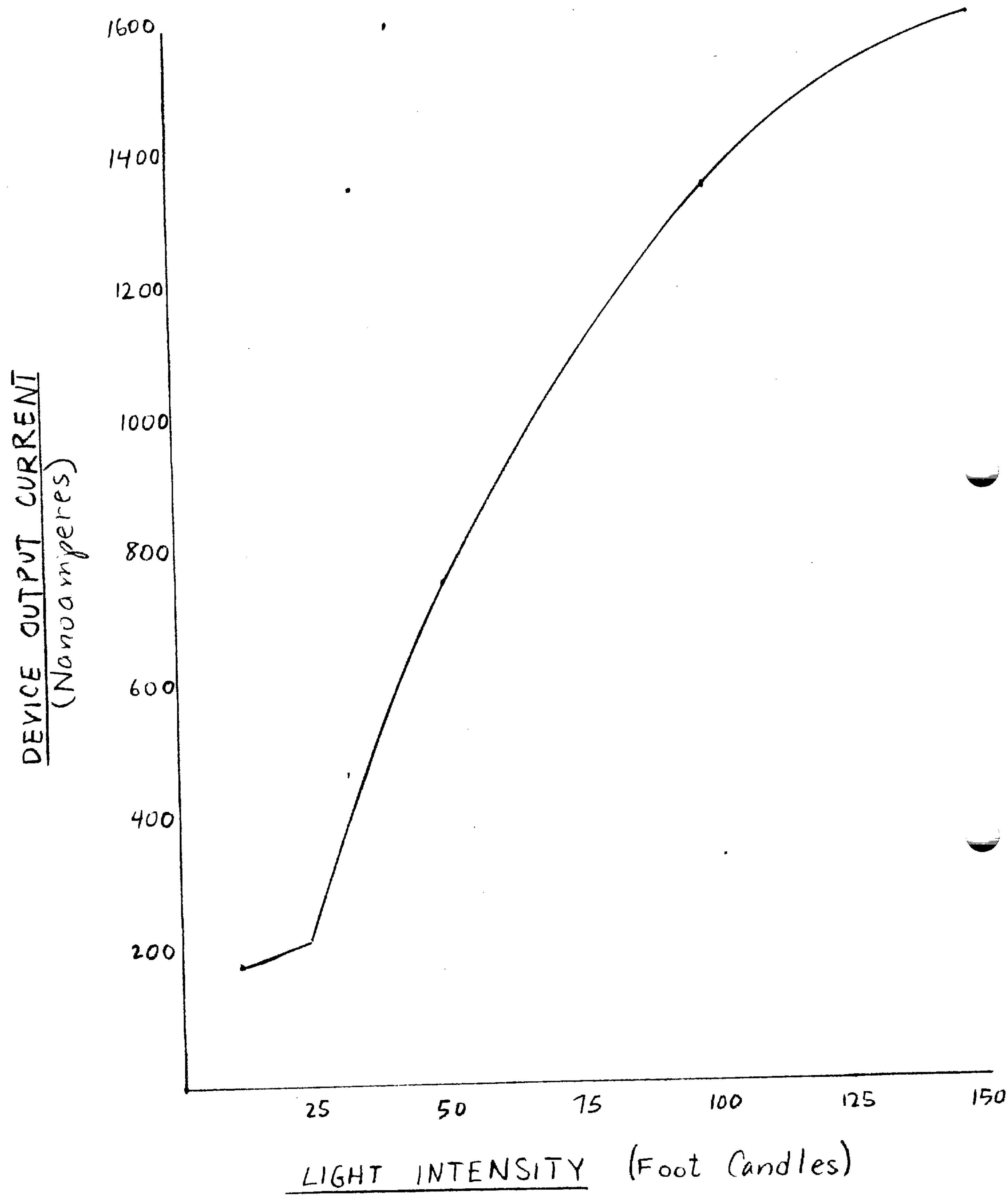


FIGURE 3 EXPERIMENTAL SETUP



SCANNING PHOTODIODE ARRAY
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